

Seasonal Forecasting of Thermal Stress Conducive to Mass Coral Bleaching Events

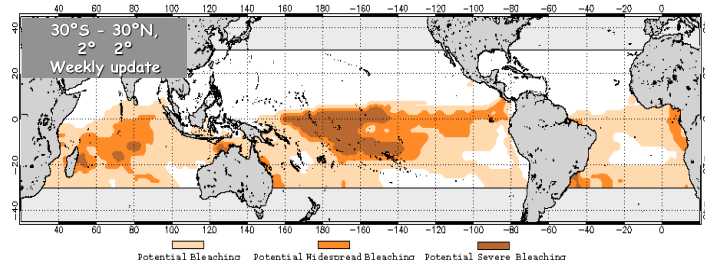


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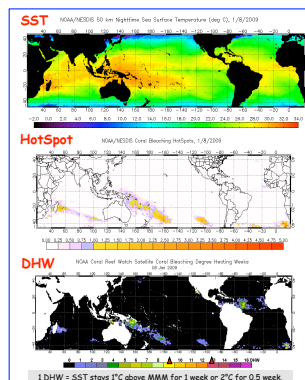
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Introduction: Coral bleaching has been increasing in both frequency and severity over the past decades. NOAA Coral Reef Watch (CRW) began providing global seasonal outlooks of thermal stress conducive to coral bleaching in July 2008. Combined with CRW's near-real-time satellite monitoring of thermal stress, this outlook has significantly improved management of coral reef ecosystems through advanced warning of bleaching conditions. The outlook system was developed jointly by CRW and Earth System Research Laboratory (ESRL). The bleaching outlook product is intended to provide large-scale patterns of potential bleaching (not for any particular reef location), thus enabling managers and scientists to prepare.

2009 Dec 01 NOAA Coral Reef Watch Coral Bleaching Thermal Stress Outlook for Dec-Mar 2010



CRW Satellite Near-Real-Time Coral Bleaching Monitoring Products (Operational, twice-weekly, 0.5-degree (~50km), Liu *et al.* 2006)



Bleaching HotSpot intensity of thermal stress as the difference between the observed SST at a grid point and the climatologically averaged temperature for the warmest month (maximum monthly mean).
Bleaching Degree Heating Weeks (DHW) intensity and duration of thermal stress associated with bleaching occurrence and intensity, accumulated HotSpot values ≥ 1.0 °C during prior 12 weeks.
 ▲ DHW >4 °C-weeks significant bleaching likely; ≥ 8 °C-weeks widespread severe bleaching and mortality likely.

References:
 Liu G, Strong AE, Skirving W, Arzayus LF (2006) Overview of NOAA Coral Reef Watch Program's near-real time global satellite coral bleaching monitoring activities. *Proc. 10th Int Coral Reef Symp*, Okinawa, Japan. 1783-1793
 Penland C, Matrosova L (1998) Prediction of tropical Atlantic sea surface temperatures using linear inverse modeling. *J Climate* 11: 483-496
 Reynolds RW, Rayner NA, Smith TM, Stokes DC, Wang W (2002) An improved in situ and satellite SST analysis for climate. *J Climate* 16: 1609-25

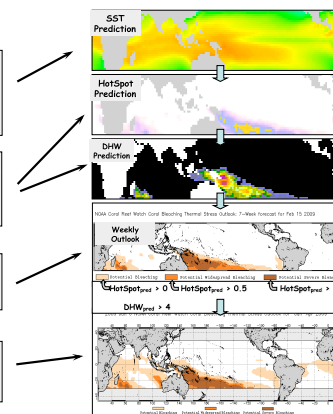
Bleaching Outlook System

(1) **Weekly SST Forecast (leadtime of 1 to 18 weeks).** Weekly SST predictions produced by the ESRL Linear Inverse Model (Penland and Matrosova, 1998). Weekly $1^\circ \times 1^\circ$ Reynolds and Smith Optimum Interpolation SST data (Reynolds *et al.* 2002) used to train and initialize model.

(2) **Weekly Thermal Stress Forecast (Bleaching HotSpot & Degree Heating Week).** Algorithm for deriving thermal stress forecasts from SST predictions modified from CRW operational near-real-time satellite thermal stress monitoring algorithm.

(3) **Weekly Thermal Stress Bleaching Outlook.** Potential thermal stress is categorized into three levels based on values of HotSpot and Degree Heating Weeks.

(4) **Seasonal Thermal Stress Bleaching Outlook.** Seasonal outlook at each $2^\circ \times 2^\circ$ grid cell equals highest potential thermal stress level among all weekly outlooks during the 4-month prediction period.



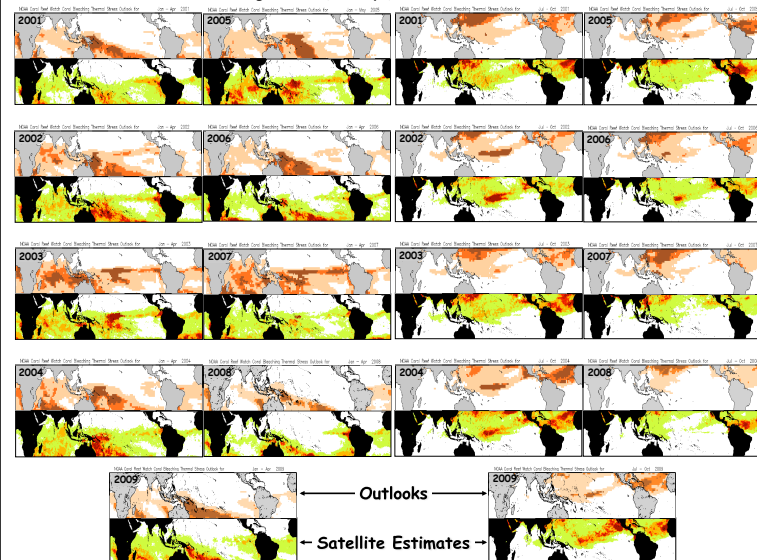
Sample Weekly Prediction for February 12-18, 2009 (based on Weekly OISST ending on December 31, 2008)

coralreefwatch.noaa.gov

Comparison of Seasonal Bleaching Outlooks and CRW Satellite Bleaching Stress Estimates

2001-2009 Austral Bleaching Season (Jan-Apr)

2001-2009 Boreal Bleaching Season (July-Oct)



Discussion and Results:

- Accuracy of bleaching outlooks are assessed for 2001-2009 boreal and austral bleaching seasons by comparing seasonal outlooks with CRW satellite bleaching stress estimates.
- Outlooks generally match observed HotSpot and DHW.
- Outlooks perform best in the Caribbean & Great Barrier Reef
- Outlooks do not perform as well in the northwestern Hawaiian Islands.
- Analyses of weekly predictions (not shown) indicate the prediction system captures timing of development and dissipation of thermal stress during mass coral bleaching events.
- Over-predicted thermal stress in the Caribbean for the 2009 bleaching season, possibly due to persistence of strong zonal winds and lack of the extra-tropical SSTs forecasts.

Future Work: In addition to evaluating and improving the current thermal stress bleaching outlook product, next steps include developing an outlook product based on the NOAA NCEP Climate Forecast System (CFS) model.



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